Limited visibility made this portion of U.S. 93 one of the more dangerous stretches of roadway in Arizona.

ARIZONA Scenic…and Now Safe

TRAVERSING THE MOHAVE DESERT ON ARIZONA'S U.S. 93

Among America's most popular roads are its scenic highways and byways; often two-lane ribbons of pavement that stretch around curves, over hills and through valleys to provide drivers with a visual feast. Unfortunately, drama and beauty can come at a price; a greater risk that driver error or unfavorable conditions can produce tragic results.

One such highway was U.S. 93 in Arizona's Mohave Desert. Otherwise known as the Joshua Tree Scenic Road, U.S. 93 cuts through northwest Arizona from the Phoenix Metropolitan Area to I-40 near Kingman. As part of the CanaMex corridor for North American Free Trade, this two-lane stretch of roadway accommodates nearly 8,000 vehicles daily, 28 percent of which are commercial trucks. It also serves as a vital link between Phoenix and Las Vegas, Nevada.

U.S. 93 was known as one of the more hazardous highways in Arizona, with rolling hills and curves that limited visibility of the road ahead. In addition, it included few safe areas in which motorists could pull over in an emergency, adding to the risk of travel through the corridor.

The Arizona Department of Transportation (ADOT), the State's Federal Highway Administration Division Office (FHWA-AZ), the Kingman District of the Bureau of Land Management (BLM), design team URS Corporation and contractor Sundt Construction spent years developing solutions, in an effort that came to be known as the U.S. 93 Boulders Reconstruction Project. The charge by Federal, State and local agencies was to widen from two to four lanes 7.5 miles of narrow, winding highway through the rugged Mohave Desert and flatten curves while maintaining the visual quality of the landscape. The team's overarching goals: to improve the capacity and operation of the roadway and reduce future highway accidents. Due to substantial environmental concerns in the area, innovative contracting, partnering and Context Sensitive Solutions (CSS) proved critical to the project's success.

Today, U.S. Highway 93 is a much safer, bifurcated (split four-lane) highway that winds beautifully through a landscape that looks as if it has remained

untouched. To surmount considerable challenges and reach their goals, project partners employed several innovations, including inventive process incentives, a road rental agreement for contractors, and ground-breaking techniques in maintaining ecological and aesthetic integrity. Other unique and forward-leaning efforts in this project include active partnering techniques and custom-designed safety training and procedures.

The U.S. 93 Boulders project now stands as a national example of innovation and teamwork, its many ground-breaking practices hallmarks of the skill and creativity advanced by FHWA's Highways for LIFE program. The project was also recognized as the 2002 Public Works Project of the Year (for projects over $10 million) by the Arizona Chapter of the American Public Works Association. In 2002, the Boulders project received the FHWA's Excellence in Highway Design Award in the "Highway Improvements on Publicly Owned Land Category." And in 2003, The National Partnership for Highway Quality (NPHQ) awarded ADOT, Sundt Construction and URS Corporation its National Achievement Gold Level Award.

Innovation by Design

Because this 7.5 mile portion of U.S. 93 serves as an important route for delivering goods and services to the residents of Kingman, Las Vegas and beyond, it was imperative that closures be minimized during the construction project. In addition, the project had to be planned to maximize safety for project workers and motorists, despite the difficult terrain.

The most innovative measure used in the Boulders project to reach the dual goals of increased capacity and improved road safety was an incentive-based contracting method. The project contract included a highly successful road rental specification that served as an incentive for the contractor; each time the road was closed for longer than five minutes, the contractor was charged a predetermined rate for every additional minute of closure.

Typically, contractors close a road for long stretches of time during certain phases of construction. But because of the volume of traffic on U.S. 93, and given the lack of alternative routes in this remote area, ADOT recognized in the early planning stages that typical road closures would not be acceptable. During initial project planning, the idea of a road-rental incentive process was introduced and quickly accepted by all partners.

This new process motivated the contractor to come up with a number of innovations and efficiencies. Because higher road rental day rates and lower night rates were established, the Sundt Construction team regularly generated new ideas to prevent the road from being closed during daylight hours. For instance, the team developed a construction-phasing plan that scheduled earthwork in a way that prevented double handling of material, saving time and money, and minimizing delays for motorists.

The Boulders team also developed a strategic phasing plan to allow half of the roadway to remain open to traffic while crews worked on the other half. The northbound construction and realignment was first priority, as it would eventually become the new highway's more heavily trafficked lanes. During the eight months required to complete the northbound phase, Sundt Construction crews worked double shifts and kept the existing roadway open to traffic.

In the end, double shifting, effective use of on-site equipment, and efficient scheduling resulted in early project completion, placing a safer roadway

in service ahead of schedule and eliminating one of the deadliest highway segments along the entire U.S. 93 corridor. Early completion also removed highway workers from a dangerous work zone sooner than anticipated.

Project incentives such as the road rental agreement and the strategic phasing plan were a first in Arizona, and are now being used successfully in transportation projects elsewhere in the State.

Partnering and Quality to Beat the Schedule

The Arizona Boulders team pursued a more active partnering method than is typically employed by the State, going beyond the obvious contribution of resources to a deep investment of time and commitment to workshops, quantitative monthly evaluations, and stakeholder consultations.

Partnering became a critical element, not only in meeting the project's ambitious schedule, but ultimately in beating it. The State and Sundt Construction, along with representatives from the Federal Highway Administration, URS Corporation, the Bureau of Land Management, the Department of Public Safety, and several subcontractors began the project with a professionally-facilitated partnering workshop. Forty-seven participants from 15 stakeholder groups set goals for quality, communications, issue resolution, team relationships, schedule, safety, environmental protection and budget. The process was so successful that ADOT now uses a similar model on all construction projects.

Commitment to the accelerated construction schedule on the Boulders project meant partners would address problems as they arose. As a result, team leaders met weekly to discuss progress. For each of these meetings, Sundt Construction's in-house Quality Assurance/Quality Control (QA/QC) staff provided detailed material reports, including gradation graphs, concrete breaks and results of density tests. Reports of these meetings were then distributed to team members via e-mail, ensuring that everyone involved was kept "in the loop." In the long run, this proactive, troubleshooting technique saved precious time by identifying and resolving many difficulties before they actually occurred.

Throughout the project, the high volume of travelers – many of whom lived and worked in distant towns – posed a serious challenge, which was intensified by the roadway's rural location. Most of U.S. 93 runs, quite literally, through "the middle of nowhere." In fact, one of the towns nearest to the Interstate is Nothing, Arizona, population 4. Consequently, communication on this effort had to be designed a little differently than on typical Interstate projects. On-site cell phone reception was difficult at best, causing project managers to work out a system of phone to fax lines for more reliable communication.

In addition, the Boulders team developed an extensive communications plan to involve customers in every phase of construction. Kaneen Advertising and Public Relations was selected to help with the far-reaching education effort. The team distributed detailed newsletters in the local towns of Wickenburg, Nothing, Wikieup and Kingman. Newspaper ads and televised public service announcements ran in Kingman, metropolitan Phoenix, and various communities throughout northwest Arizona. Additionally, the news media was kept informed with regularly scheduled briefings and project tours.

Congestion was nonetheless inevitable along the construction route, due to the narrow width of the road and the volume of traffic. The Boulders team continued to analyze the challenge throughout the project and adapted methods to improve traffic flow. When the aftermath of an initial blasting operation produced a roadway closure of several hours, Sundt, its subcontractors and ADOT

representatives met to evaluate and adjust the procedure. For future blasts, Sundt and ADOT contributed funds and manpower for additional equipment to clear the road and for placement of message boards providing motorists with advanced closure warnings. The team also provided water and portable toilets along the route for the comfort and safety of motorists – also providing a valuable precaution should unexpected, lengthy delays be encountered.

Safety, an Overarching Concern

Safety for motorists remained an overarching concern throughout the 18-month construction period. Despite the rugged terrain and the challenges posed by the harsh environment, only one serious accident occurred during the length of the project. Records also show a significant decrease in the number of severe highway accidents on the roadway since project completion, an even greater measure of success.

Additional measures were also taken to ensure worker safety during construction. These included daily meetings among all workers to discuss safety precautions and procedures prior to executing each day's plan. Workers also had to complete safety training specific to the U.S. 93 Boulders project. A task force from ADOT's safety department made frequent onsite visits to monitor work in progress and report any infraction, potential risk, or "near miss" observed. In addition, crews formed their own safety teams to discuss issues that might arise from each phase of work.

These efforts produced a remarkably safe work environment in a challenging location with many high-risk exposure opportunities. Only one serious safety incident occurred during 190,207 man hours worked in the entire 18-month project, and only 4.2 lost-time injuries occurred per 1,000 hours worked. In recognition of its commitment to safety on the project, Sundt Construction earned the ADOT Exceptional Safety Performance Award.

Doing It Right the First Time

Just as acceleration of construction did not create compromises in safety, innovations that boosted efficiency did not come at a cost to quality. Quality control standards were established well before the Boulders team broke ground, with URS Corporation implementing a stringent QA/QC plan. This

Ice age glacial activity left the area littered with rock formations. Almost 3,000 of these rocks had to be relocated during construction.

plan enhanced the design by ensuring that products and deliverables met ADOT requirements "the first time." Using mobile labs, Sundt Construction's QA/QC staff members performed quality control tests on project materials at the Boulders site. Off-site sources were pre-tested in other facilities to ensure their quality before they arrived on the job. The plan also included a comprehensive system of checks and reviews so products would require little to no reworking, which further propelled project completion on schedule and within budget.

A smoothness and quality contractual incentive ensured that the final product reflected the high standards of the Boulders team. Superpave mixes, for instance, can be susceptible to moisture-induced stripping and require expert mixing and handling. Subcontractor Staker Paving used a mobile transfer unit to improve the consistency of the Superpave asphalt mix. The unit maintained temperature uniformity and gradation throughout the mix, resulting in a smooth, even, and moisture-resistant roadway.

The contractor also earned a Letter of Commendation from ADOT in the area of administration; it consistently submitted accurate, timely and complete payrolls, which ultimately saved the Boulders team time and money.

Quality processes throughout the Boulders project helped contractors get in, get out, and get it right the first time. The result was project completion in only 310 days, nearly 8 months ahead of schedule.

Context Sensitive Solutions; Blending Highway and Environment

The Arizona Boulders Project reflected Context Sensitive Solutions (CSS) from start to finish, in an effort to provide an end product that exceeded the needs of customers. The project was conducted in harmony with the community and preserved environmental, scenic, aesthetic, historic, and natural resources in the area. In fact, comprehensive environmental and aesthetic requirements from BLM helped drive project planning.

Among broad CSS considerations that contributed to the success of the project were that:

- the project exceeded the expectations of designers and stakeholders and achieved a level of excellence from the customers' perspective;
- it involved efficient and effective use of the available resources (time, budget, community) of all parties involved;
- it was designed and built with minimal disruption to the local community; and
- the project is viewed as adding lasting value to the community.

A closer look at the project spotlights specific CSS successes. First, highway projects in the high desert generally involve exceptional consideration of the environment, including wildlife and native flora. Less common, however, is special attention to the mineral world – rocks, cliffs and boulders. On the Boulders U.S. 93 project, rocks and geological formations were handled with as much care and sensitivity as plants and animals, making this project environmentally unique.

Next, the project crossed through lands overseen by the BLM, requiring that every phase of construction focus not only on the safety of motorists, but also on maintaining the visual beauty of the landscape. Teams worked closely with the BLM to incorporate environmental mitigation standards that ensured the protection of the sensitive desert ecosystem.

Such efforts produced a number of distinct challenges. Chief among these was the need to cut 100 feet into granite bedrock, with embankments up to 70 feet high. In these sensitive areas, experts from Geological Consultants gathered rock structure data to determine joint and fracture patterns and analyze stability. The analyses were used to determine cutting methods that minimized blast excavations.

With key earthwork factors identified, the team also made adjustments to horizontal and vertical alignments and cut ditch widths and slopes to gather additional material. Disposal of excess material was achieved by flattening embankment slopes and creating false cuts. The cuts and fills were then analyzed using three-dimensional drawings integrated with MicroStation design and Digital Terrain Model (DTM) files. The team then warped, sculpted, and stained the new slopes and rock to ensure that the earthwork blended seamlessly with the existing landscape.

Modern Techniques Meet Ice Age Terrain

The project's namesake, boulders, posed a significant challenge to the success of the project. Ice age glacial activity had dotted the landscape with millions of rounded multi-ton rocks, some of which are stacked delicately on top of one another. These unique formations are among the factors that helped earn U.S. 93 a scenic highway designation. A major issue for the project team was how to handle the boulders during construction. The team determined that the best option for preservation of the landscape was to temporarily relocate the boulders – approximately 3,000 of them – and reset them exactly as before when the project reached completion. Extensive mapping and planning were required to achieve this Context Sensitive Solution.

To complicate matters, Federal land agency standards required the boulders to be reburied at various levels in the ground to recreate, as closely as possible, the look of the natural environment. This meant the rocks could not sustain any significant scarring or breaking. The team had to custom modify existing equipment to protect the boulders during relocation, "With some minor adjustments, we were able to secure a 'thumb' attachment to a backhoe," said Hedy Bagherpour, Project Manager for Sundt Construction. "The thumb attachment allowed us to actually grab the rocks. This way we could hold them securely in place so that they wouldn't be significantly marred."

Re-planting a saguaro cactus. The Boulders team salvaged over 20,000 cacti and plants during the course of the project.

The pioneering claw attachment, a first of its kind, allowed the team to bury and place the salvaged boulders at various levels in the ground, unscarred by the removal process, thereby duplicating the natural boulder-strewn appearance. The equipment innovation provided a useful lesson in meeting the requirements of similar geographic conditions.

Salvaging the Flora; A New Paradigm

One might assume that having to carefully move, then replace, over 3,000 boulders would have posed the greatest challenge to the U.S. 93 reconstruction team. According to Bagherpour, however, relocating the flora proved to be an even more delicate task. Over 20,000 native plants had to be removed, maintained, and replaced during construction.

For any desert construction project, BLM requests that great care be taken with the various desert plant species. As part of the native plant salvage and revegetation plan, the majority of the plants within the roadway disturbance area were replanted or reseeded using materials salvaged from the project.

The Boulders project relied heavily on teamwork and partnership, setting a standard for environmental mitigation in this sensitive rural area, again a model of the CSS process. The work provided the traveling public with a smoother, wider, and safer roadway without sacrificing the natural beauty of the land. For a number of years, ADOT has made salvage and replanting of vegetation a standard practice on projects statewide; however, the Boulders project was perhaps the most extensive salvage effort ever undertaken by the agency.

“Our initial plans included salvaging many of the plants,” added Bagherpour, “but it’s a very expensive process. BLM wanted us to try and save a lot more.” Sundt Construction and sub-contractor Revegetation Services went back to the drawing board and, after conferring with ADOT, developed a far more ambitious plan. Nursery areas were constructed onsite so the salvaged species could be preserved in soil conditions similar to those from which they were removed.

To ensure that the plants and cacti received adequate moisture, the team needed a watering system for the onsite nurseries. Revegetation Services rose to the challenge and custom-built an entire irrigation framework for the refugee flora. In the end, the use of nursery facilities, along with stringent quality control measures, achieved a plant survivability rate of over 90 percent.

The Boulders team is now working with ADOT to revise the specifications for plant salvage on future projects. An on-site nursery, with professional landscapers managing it at all times, was a key lesson learned and has been adopted as a practice on other Arizona roadway construction sites. The watering and shading system reversed a traditionally low plant survivability rate and will be deployed elsewhere. The revised ADOT specifications for plant salvage, based on the Boulders’ success, also include clearer direction on timing, quantity and financial compensation needed to ensure stronger outcomes.

Taking Care of People…and Other Creatures, Too

People and native plants may call the Mojave Desert home, but it is also the domain of coyotes, tortoises, mountain lions, gila monsters, deer and other animals. The team worked closely with BLM to minimize the project’s impact on wildlife, devising accommodations that would benefit animals during and after construction.

Of particular concern was the fact that transforming U.S. 93 from a two- to four-lane highway created a more hazardous environment for animals that might wander onto the roadway, which in turn could endanger motorists. To keep the animals away from traffic, the team installed approximately 6,000 feet of wildlife game fence that stands 7'-10' tall. The team also added approximately 80,000 linear feet of wire mesh fabric to the bottom eighteen inches of most fences to prevent smaller species such as the desert tortoise from entering the roadway under the fence. The wire mesh was also buried or stapled to the ground to prevent tortoises from burrowing under the fabric. This practice, an innovation of the Boulder's project, is now considered a best practice in Arizona, and has been used in other highway construction projects.

"Pre-construction surveys of most work areas were required to clear construction areas of critical species, such as the Sonoran desert tortoise, gila monster and the rosy boa," said ADOT Project Manager Larry Doescher. "The tortoise fence was then designed as a permanent installation to help ensure protection went beyond construction. To date, the State has installed many miles of this fabric up and down the corridor in an effort to mitigate adverse impact to the desert tortoise."

As part of the comprehensive desert tortoise protection plan implemented by the team, twelve smaller culverts were situated to allow tortoises to cross underneath the roadway. "Tortoise training" was mandatory for all crews to bolster the safety of this species, a true stakeholder in the construction project. Before working on the site, each crew member was required to review an instructional video that outlined steps for safely removing tortoises from the construction area.

Other drainage culverts constructed along the highway were designed with wildlife in mind, as well. Three extra large culverts were carefully spaced along the project length to allow deer, mountain lions, and other larger species safe passage beneath the redesigned U.S. 93.

A Shining Success Story

In praising the outcome of ADOT's extraordinary efforts, NPHQ Executive Director Bob Templeton commented, "The Boulders Project embodies the best practices of the highway quality movement, and its success is reflected in key quality measures. Besides taking stellar environmental mitigation measures, the team finished the $16.3 million effort 8 months ahead of schedule. To stay ahead and to minimize traffic disruptions, some crews worked double shifts on one of the deadliest sections of roadway in the State. Perhaps the greatest achievement actually occurred after completion of the project: the number of severe highway accidents has decreased significantly. This undertaking exceeded customer expectations, which, at the end of the day is the goal of all great highway projects."

Sundt Project Manager, Hedy Bagherpour, attributed the success of the project to teamwork. "We couldn't have done this without ADOT, BLM and all of the team members. Everybody worked hard to finish this project ahead of schedule. The level of cooperation was really amazing."

Since project completion, roadway accidents have been reduced, while scenic beauty has been preserved for local motorists and visitors. New standards of excellence have been set across a wide spectrum of practices for Arizona DOT, increasing the agency's service to its customers and improving future operations.

The new U.S. 93 corridor lives in greater harmony with its environment, habitat, and animal neighbors and serves as an example of the way in which man's vision of the future can be interwoven successfully with the landscape of the past. All are outstanding achievements that inspire roadway professionals to reach for new heights in their quest to deliver Highways for LIFE.

The Boulders team transformed a 7.5-mile stretch of U.S. 93 from a two-lane roadway to a four-lane highway.